Flow and Transport Through Porous Media: II
Chem. Eng. 671: Multidimensional Transport

Instructor: George J. Hirasaki; 348-5416, AL245, gjh@rice.edu

Scheduled meeting: M&W, Friday make-up, 4:00-5:30, KECK 105

Credits: 3

The course is designed for graduate students interested in the flow of multi-phase, multi-component fluids through porous media with application to oil and gas recovery and aquifer and soil remediation. Part I, taught during alternating years, emphasized geology, chemistry, and physics with transport computation limited to one dimension. Part II, emphasizes computation of multi-dimensional systems. It is helpful to have Part I first but not required.

The grade will be based on problem solving with students encouraged to collaborate. However, copying is not acceptable. Each assignment will have a due date at which time the solution is distributed. Assignments turned in after the due date or reworked parts of assignments will receive 80% credit. Computation and graphic presentation of results may be done with tools such as Matlab, or Excel. Part II, taught in the spring semester, will use FORTRAN, MATLAB, or C.

Reference Textbooks:

Reservoir Simulation, C. C. Mattax and R. L. Dalton

Course Outline: Attached

Flow and Transport Through Porous Media II

Chem. Eng. 671 Multidimensional Displacement

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Finite Difference for Fractional Flow Equation
- Differential equation
- Up stream weighting
- Explicit or Implicit
- Truncation error
- Stability analysis
- Time step selection

Dispersion
- Mechanisms for dispersion
- One dimensional convection with dispersion
- Estimation of dispersion coefficient
- Mixing zone growth
- Finite slug

Hydrostatic Fluid Distribution
- Capillary pressure definition
- Capillary pressure curves
- Scaling of capillary pressure
- Hydrostatic fluid distribution
- Three phase distribution
- Reservoir seals
- Outflow boundary condition
- Methods of measurement
- Capillary pressure models
- Effects of wettability

Finite Difference in 1-D with Capillary Pressure
- Differential equation and boundary conditions
- IMPES formulation
- Semi-implicit formulation
- Block tridiagonal matrix

Multidimensional, Multiphase Displacement
- Generalized material conservation equations
- Hydrocarbon phase behavior
- Particular fluid systems

Finite Difference Solution in Multidimensions
- Finite difference in time
- Regular grid spacing
- Variable grid spacing
- Material balance check
- IMPES formulation
- Semi-implicit formulation
- ADI
- Preconditioned Conjugate Gradient

Reservoir Geometry and Properties
- Curvilinear coordinates
- Cylindrical r-z coordinates
- Reservoir geometry

Well Models
- Relation with grid block
- Well impairment
- Saturation dependence
- Well common to several grid blocks
- Vertical lift performance
- Oil-water coning model

Reduction to Two Dimensions
- Averaged Conservation Equations in Two Dimensions
- Vertical Equilibrium
- Calculation of Distributions and Averages of Saturation, Relative Permeability, and Capillary Pressure
- Reservoirs with Negligible Capillary Transition Zone
- Reservoirs with Large Capillary Transition Zone
- Reservoir Thickness and Average Saturation
- Stiles-Hearn model for layered formation